THE FUTURE OF NICKEL AND THE LAW OF THE SEA

Ministry of Natural Resources
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Mineral Policy Background Paper No. 10

Une version française de cette publication est aussi disponible sur demande.

February 1980

Price: $1.00

ISSN 0706-103X
ISBN 0-7743-4792-9

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Foreword

Widespread misconceptions about the nature of the nickel reserves of Ontario, Canada and other land-based producers have led to overly optimistic views about the near term potential of sea bed mining. These could lead to premature and possibly subsidized development of sea bed mining capacity, which could have serious effects upon present and potential land-based nickel producers here and in the developing countries.

In the following pages, the Mineral Resources Branch of my Ministry have laid out in simplified form, key facts and analysis bearing on the future of the nickel industry and the proposed United Nations Law of the Sea.

The objective is to provide information for the use of those having an interest in the nickel industry. I hope it will also contribute to a better understanding of the problems involved and the debate over sea bed mining development.

James A. C. Auld

Minister of Natural Resources

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Conclusions

This very much simplified picture of the issues surrounding the question of how the development of sea bed mining might impact land-based operators leads to the following conclusions.

1. Under any realistic assumptions there is no doubt that the nickel reserves of the Sudbury basin and of Manitoba will be adequate to meet their current market share at acceptable world market prices for the foreseeable future, that is well into the next century. Sudbury's and Manitoba's customers in the United States, Western Europe and Japan can be assured that Canada's nickel supplies are adequate and secure to meet its share of future requirements – and will do so at competitive prices provided ore is not turned into waste by excessive institutional constraints on input factor usage. Indeed, with current cost trends the further exploration for new or extension of existing sulphide deposits may be the best bet to assure the most economic supply of nickel through the next century.

2. Sea bed nodules as a source of nickel supply for the remoter future are still surrounded by many unknowns which make investment in sea bed mining extremely risky – unless extraordinarily optimistic forecasts regarding future demand developments are accepted. These risks cover the whole spectrum from exploration and delineation of nodule beds adequate for mine planning, through the problems of actual mining and hoisting to the surface as well as smelting and refining, to the still unresolved legal issues connected with the U.N. Law of the Sea Conference, and the questions surrounding royalty or taxation levels to be imposed by the U.N. Seabed Authority on ocean mining operations – which may be quite high.

3. Under present and foreseeable circumstances, it does not appear likely that any sea-bed mining will take place on a commercially significant scale at least before the late 1980's or the 1990's and quite possibly not until much later. This does not rule out the continuous interest of resource companies in this potential future supply or a limited amount of expenditures for research and development or even extensive 'pilot plant' operation.

4. *The ceiling formula for future sea bed production contributes to increased stability of markets* under conditions of high risk and high cost development of unconventional technology through the brakes it puts upon precipitate development of excess capacity based on overly optimistic market forecasts. *The guaranteed floor concept would introduce a significant element of instability into the industry* and could in a very real sense become a cause for otherwise unnecessary shut-downs and highgrading of land-based operations as well as of increased consumer prices for nickel products. The implementation initially by major importing states and later internationally of the rationing and dual pricing system necessary under the guaranteed floor formula would present incredible difficulties.

5. Under realistic assumptions regarding the future development of nickel markets, the interests of land-based producers from both developed and developing countries throughout the world would coincide with those of the industrial consumers of nickel metal in North America, Europe and Japan and ultimately with those of the final consumers of nickel containing products.

6. The drive towards incorporation of a guaranteed floor formula for sea bed nickel production appears to be based upon fear on the part of its advocates of the implications of downward revisions of earlier excessively optimistic forecasts regarding the development of nickel demand, combined with excessively pessimistic ideas regarding the capacity of the market system to deal with problems of introduction of non-conventional technology. Both of these ideas appear to be based very largely upon the totally discredited ideas of the "Club of Rome" and other interventionist concepts which if implemented, would retard the further progress of the developed nations and totally impoverish the Third World.

7. With the significant progress already achieved at the U.N. Law of the Sea Conference in the last five years, and in view of the vital importance of the issues to be resolved, Canada, with the participation of Ontario, remains dedicated to the satisfactory conclusion of the negotiations, which will protect both mining and maritime interests, and will guarantee orderly and lawful utilization of the oceans above and below the surface. This has been the objective of the Federal and Provincial governments, and of the Canadian Law of the Sea Delegation, from the very outset of the negotiations, and most recently at the 1979 summer session. Ontario will continue to support these efforts in 1980, when the Conference is expected to enter the decision-making stage.

I. Introduction

Lately a question has arisen whether there is a long term future for the nickel industry of Ontario at Sudbury and Port Colborne – and possibly other potential locations in Ontario and elsewhere in Canada. It has been suggested that this future is seriously jeopardized through current developments with regard to future mining of deep sea bed nodules, at the United Nations Law of the Sea Conference. Sea bed mining would affect the future of land based nickel mining everywhere.

The sea bed nodules will produce the same three commercially important metals as Sudbury: nickel, copper and cobalt. Speculation has been fired by statements in various countries regarding the nature and life of Sudbury's nickel reserves, regarding the likely development and rate of growth of sea bed mining, the question of marketing the metals contained in sea bed nodules, and regarding the possible effects of sea bed mining developments upon all land based nickel mining.

In light of disruptions of nickel production in recent years and of Sudbury nickel's declining share of world markets during the period since World War II, it is understandable that these concerns have reached serious proportions. However, while absolute certainty about the future cannot be achieved, of the mining or any other industry, it does appear that some of the fears currently voiced abroad are excessive.

Concerns over long term physical resource availability were regenerated over a decade ago by the now solidly discredited 'Club of Rome' report. They still worry major mineral commodity consumers, particularly those countries which do not produce a significant proportion of their own consumption. These worries have been strengthened by serious political interruptions of supply in various other commodity markets which had nothing to do with geological reserves of nickel or with the problems of ultimate resource adequacy.

The Ontario Government is as concerned as the people who earn their living in the nickel industry regarding the health of this crucial and very highly productive segment of our economy. Some basic facts in the following section highlight the importance of the nickel industry in the economy of Ontario and set it in perspective.

The purpose of this paper is to acquaint the concerned public with some facts and with some fundamental analysis to dispel unwarranted fears.

II. The Value of Nickel to Ontario

Figure I gives an image of the role that Ontario nickel plays in the provincial economy. The value of nickel produced in Ontario is equal to only about 1.3% of the Gross Provincial Product. However, it is equal to 4.5% of the value of imports into Ontario and equal to about 6% of the value of exports from Ontario. In Canada 3.4% of Gross National Product is derived from metal mining as compared to .3% for the United States. Ontario accounts for over 40% of the value of Canada's metal production and nickel accounts for over 40% of the value of Ontario's and for over 20% of Canada's value of metal production.

Figure 2 puts the value of nickel into relation with key products of the Ontario agricultural sector, which most people know more about than mining. The value of Ontario produced nickel is equal to about 52% of the cash income to Ontario farmers from livestock sales, or equal to 96% of cash income to Ontario farmers from total crop sales. It is 1.88 times the cash income to Ontario farmers from the sale of dairy products and 2.92 times the value of cash income to Ontario farmers from the sale of hogs.

Clearly any industry of such magnitude is of prime concern and worthy of vigorous efforts to ensure its continued health.

Fig. 1

The Value of Ontario Nickel

a) in relation to GPP, imports and exports

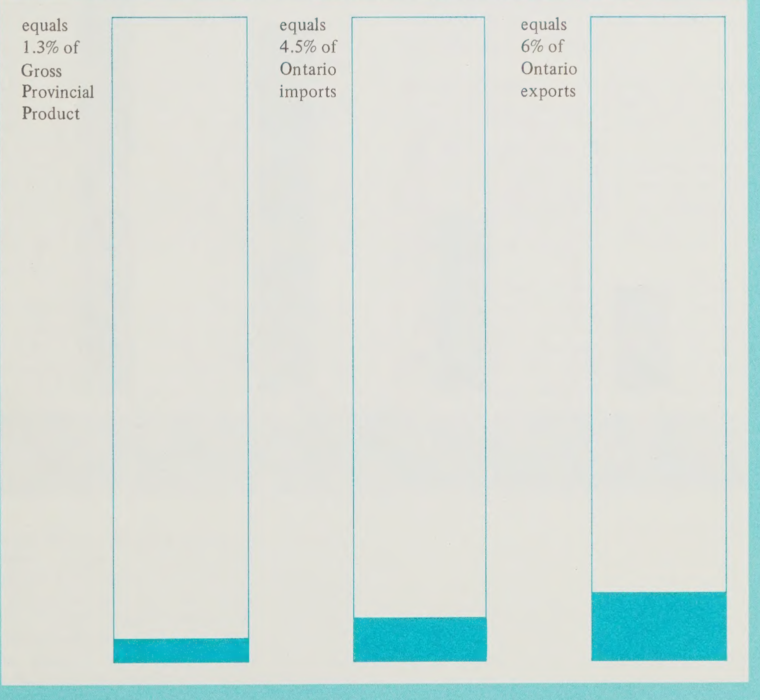
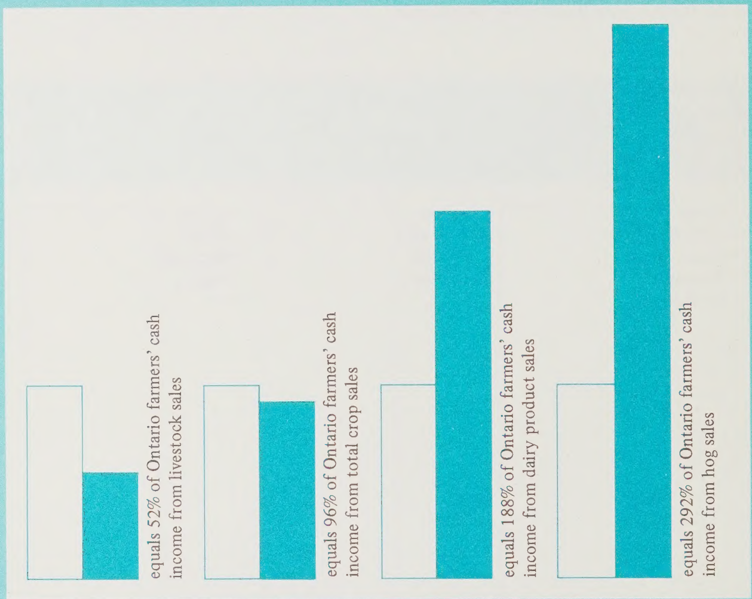


Fig. 2

The Value of Ontario Nickel

b) in relation to agriculture



III. The Role of Sudbury Nickel in the World

Since World War II, Sudbury's and Canada's share of the world nickel market has declined from over 80% to just under 25% for Ontario and just above 35% for Canada as the contributions of some newcomers and some old competitors increased. However, the tonnage of Sudbury's annual nickel output has risen noticeably in the same period. Figure 3 shows the percentage distribution changes of world nickel production that have occurred since 1947 and indicates the different patterns followed by Ontario and Canada, by the Centrally Planned Economies and by the developing countries. Part of the competition came not from new mines producing from sulphidic ores of the Sudbury type but from new mines producing nickel from lateritic ores. Lateritic ores while less expensive to mine are more energy-intensive to process. The share of lateritic production has increased from about 10% in 1950 to just under 40% today (Figure 4). Due to economic conditions further inroads of lateritic nickel on the market share of sulphidic nickel seem to have slowed down for the time being. However, the development of high grade laterite deposits particularly in some managed economies continues.

Future increases in world energy prices would make it more difficult for lateritic nickel producers (currently accounting for some 40 per cent of world production) to compete since energy costs already account for between 50 per cent and 55 per cent of their total production costs. On the other hand it may be argued that if one considers the 'gold price' of oil, energy prices in real terms have not changed all that much and that increases in dollar prices of oil largely reflected inflation. Furthermore there is nothing inherently irreversible even about dollar price increases of oil. Lastly, energy is to quite an extent a substitutable input into production processes. Thus a case can be made that laterite nickel may see another expansion phase in the future.

To consider only the percentage distribution changes in production would be misleading. Levels of physical production of nickel – both for Ontario and for Canada as a whole – since the steady increases from 1946 to the mid 1960's have shown a tendency to stabilize in the range of 250,000 metric tons of nickel contained in ores mined in Canada, and in a range of 175,000 to 200,000 metric tons of nickel contained in ore mined in Ontario. These trends are indicated in Figure 5 and reflect the ability of known sulphide deposits to sustain production far into the future.

Figure 6 shows the corresponding increases in the value of Ontario's nickel output. Values are shown in current Canadian dollars as well as in 1972 Canadian dollars to indicate the effects of inflation. The diagram shows that there has been a steady increase from just over 100 million in 1972 Canadian dollars per year in 1946 to the half-billion dollar range in 1972 Canadian dollars by the late 1960's and then indicates stabilization around this figure. This trend in deflated dollars is somewhat obscured by the picture in terms of current Canadian dollars where we see a fairly steady increase again from the end of World War II until the late 1960's and then a steeply increasing trend until 1977. This last increase is, of course, pure inflation.

The increase in physical and value output of the Ontario Nickel Mining Industry was achieved in spite of increasing foreign competition and was accompanied at first by increasing levels of direct employment and later by stabilization of that level. Employee earnings rose steadily in current and in deflated dollars from 1946 to the late 1960's. Then the divergence between steeply rising earnings in current dollars and virtually constant per capita earnings in deflated dollars highlights again the progress of domestic inflation in Canada. These trends are illustrated in Figures 7, 8 and 9.

Increasing competition did not jeopardize either the growth or the stability of mining in Sudbury. Rapidly increasing consumption of nickel, particularly in Europe and the Far East, provided new outlets for increasing world wide production. The achievements of Ontario's nickel industry are the more remarkable since they occurred despite the fact that some competitors, particularly in the planned economies of the communist countries as well as in some developing countries, received significant subsidies from their governments.

The improvements in industry performance, as well as in miners' earnings, were only possible through massive levels of capital investment. The capital invested per miner has been steadily escalating. Over the last 5 years capital investments in Ontario's Nickel Industry ranged from 60 to over 70 million dollars per year. During the major capacity expansions of the late 1960's and early 1970's capital investments were also of major significance and exceeded $1 billion in Canada, most of it in Ontario.

The average miner who at the end of World War II commanded equipment ranging from a few hundred to, at best, a few thousand dollars, today operates equipment ranging from several tens of thousands to over a hundred thousand dollars in value. The nickel industry in Ontario today is not only a major employer but is a major market for mining and processing equipment. In these two categories of equipment, Canadian content in each of the subcategories of initial cost, replacement cost and maintenance is over 50 per cent.

Fig. 3

Percentage Distribution of World Nickel Production

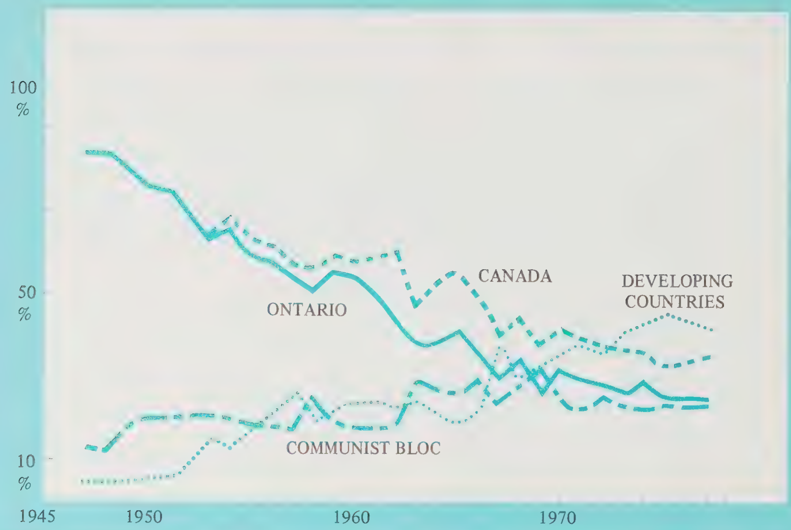


Fig. 4

Percentage Distribution of World Nickel Production by Ore Type

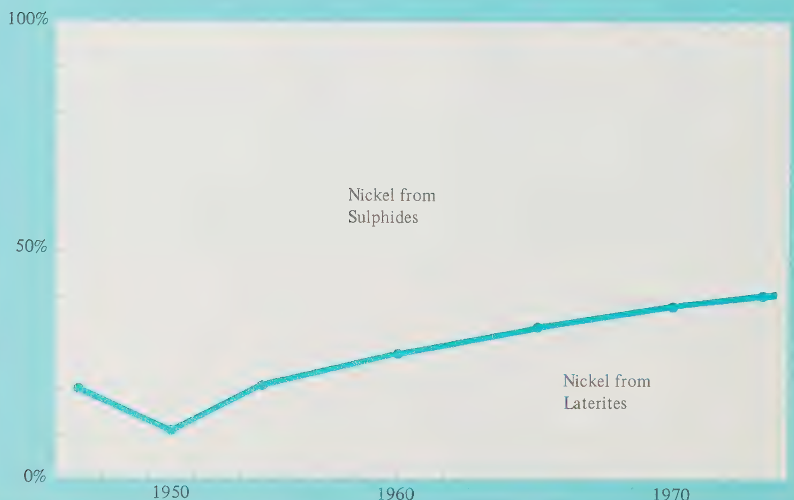


Fig. 5

Production of Nickel – Ontario and Canada

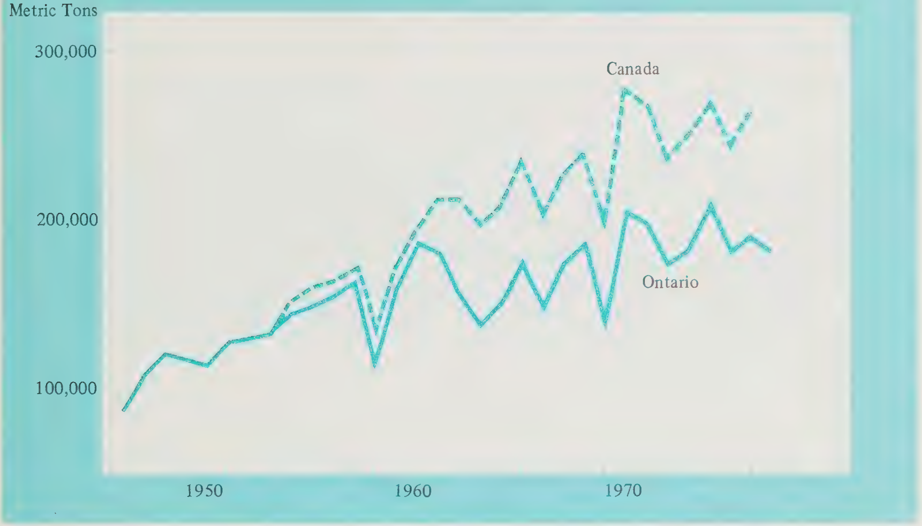


Fig. 6

The Value of Ontario's Nickel Output

in current and in 1972 Canadian Dollars

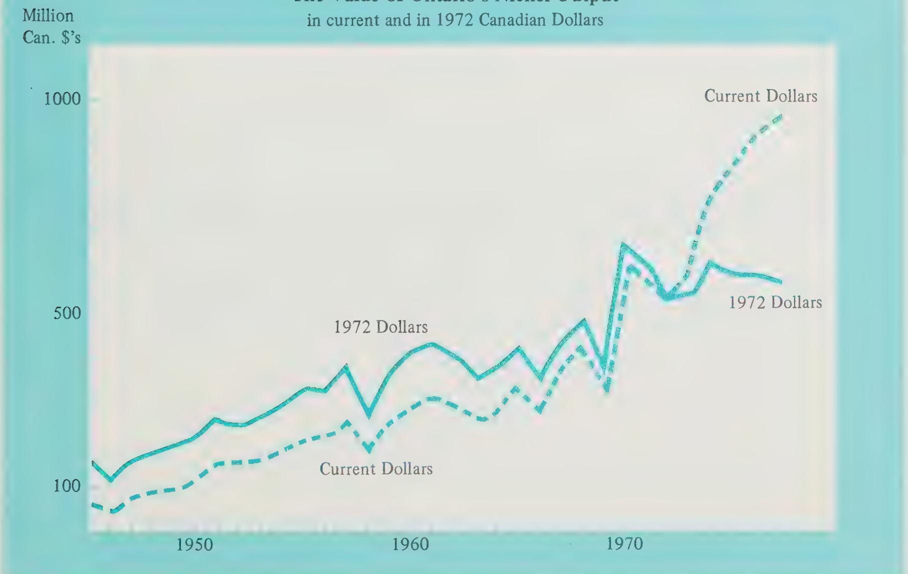


Fig. 7

Direct Employment in Ontario's Nickel Industry

in man-years worked.

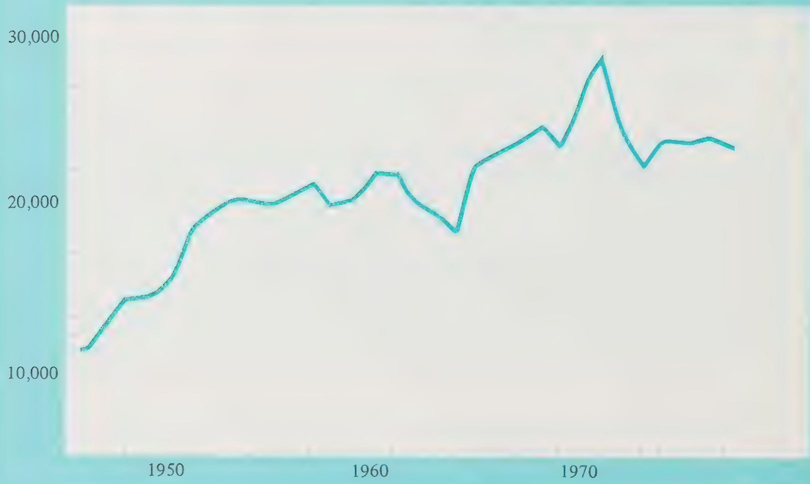


Fig. 8

Ontario Nickel Industry Payroll

Wages and Salaries in current and 1972 Canadian Dollars.

Fig. 9

Ontario Nickel Industry –Earnings per Man-Year

Wages and Salaries in current and 1972 Canadian Dollars.

IV. The Canadian Reserves of Nickel Ore

From 1945 until 1978 INCO's Canadian reserves increased from 217 million short tons of ore to almost 400 million short tons of ore. INCO's Canadian reserves of contained metal, nickel and copper combined, during the same period increased from 6.9 to 10.8 million short tons. That means that the overall grade of the reserves decreased only slightly, a decrease compensated for through improved extraction technology. During the same period, allowing for annual fluctuations in response to fluctuating consumer demands, INCO's production trend also showed that annual output doubled or possibly more than doubled. Figures 10, 11 and 12 show respectively, the development of INCO's Canadian reserves in million short tons of ore, in million short tons contained nickel and copper, and INCO's Canadian annual production in tons of ore mined. INCO data are being used to illustrate a general point. Falconbridge data tell a similar story. The output of Falconbridge fluctuates around 14% of that of INCO.

The INCO figures mean that while output has increased, the reserves – whether expressed in terms of ore or in terms of contained metals – have also increased. For Falconbridge's Ontario operations ore reserve tonnage showed some decline while metal reserve tonnage remained steady. *As ore was mined each year, new ore was proved and developed.*

Combining the figures on reserves and the figures on production, yields what is known as the reserve ratio, the reserves in any particular year divided by that year's rate of production. After an adjustment period immediately after World War II, which reflects essentially the reopening of world markets after the years of war time production, INCO's reserve ratio has stayed fairly constant, showing a trend increasing from the 17 to the 20 year range. Regardless of annual production the number of years that developed reserves would last, given that particular year's production, has not decreased. If the reserves available in 1952 had not been augmented and if that particular year's rate of production had been sustained, INCO's Canadian operation would already have run out in 1971.

The data published by industry have been monitored and checked carefully by staff of the Ontario Ministry of Natural Resources. As a result of this work the Ministry can state that there is no reason to question the validity of this published information.

For the reader, a legitimate question is why, if ore that has been mined out can be replenished in the reserves on a year by year basis, a mine does not establish early in its life once and for all its ultimate reserves? The reason is similar to that of a shoe store which does not put on its shelves all the shoes it ever wants to sell. Inventory costs would simply be too high. So it is with a mine. It costs a great deal of money in on-site exploration and development costs to prove up new reserves, and it is too expensive to incur these costs simply in order to prove reserves into an indefinite future. A mine, like any other business or industrial establishment, has a sensible financial planning horizon which is dependent on forecasts of interest rates and commodity markets as well as on other factors. For a major Canadian base metal mine this is typically in the range of 10 to 20 years, the period it takes to write off even the biggest capital items. This planning horizon expands with declining real interest rates and increasing stability and contracts with increasing real interest rates and deteriorating stability. In addition, except in cases of ore bodies which are very limited in extent, it takes time to develop the geological concepts necessary to control intelligently exploration for new reserves, and consequently accelerated exploration programs are often unsuccessful or even counterproductive.

The Ministry of Natural Resources, on the basis of its independent studies, concurs with INCO that the current pattern of replenishing reserves as they are mined can continue well into the next century given reasonable stability of the institutional framework within which industry must operate. The same principle applies to Falconbridge and to Canadian metal mining as a whole.

THERE IS NO GEOLOGICAL REASON TO FEAR THAT ONTARIO NICKEL PRODUCTION WILL NOT CONTINUE LONG INTO THE NEXT CENTURY.

There is, however, one caution that should be registered. This is the fact, also established by Ministry internal studies, that Ontario's nickel reserves and reserve ratios are sensitive to significant changes in cost/price ratios much more than to annual rates of production. Should the spread between the revenue that can be realized from the sale of a pound of nickel and the cost of producing it be significantly reduced, much of the metal-containing rock that now constitutes reserves would become valueless. Many ore blocks would cease to be profitable and many stopes would no longer be classified as ore. Herein lies the greatest danger for the long term future of Sudbury. The spread can be reduced on the one hand by any significant future drop in nickel prices. In light of the probability of continuing small but steady increases in nickel consumption, of which more later, this is not too likely to happen, unless of course sea bed nickel or other significant new producers subsidized by their host governments come on stream.

The greater probability is that such a decrease in the cost price spread would occur due to increases in costs. In as far as one can hold that "sunk costs (money spent in the past) are irrelevant", short term increases – and this would cover periods of even several years – in the costs of capital are not likely to be very significant. One set of factors that would make *significant* differences are massive increases, relative to the price of nickel, in direct and indirect labour costs. Such increases are today most likely to result from further constraints to the labour market rather than from the operation of market forces. Another set of such factors would be massive mandated non-productive expenditures to achieve further reductions in pollutant emissions (Sudbury's air is now cleaner than

Toronto's). These latter investments would achieve no significant further increases in local air quality, nor would regulations that further limit emissions, which in effect limit the quantity of metal a company may produce.

Detailed studies indicated that the effects upon investment levels – attributable to the Federal and Provincial changes in taxation and in environmental legislation which occurred in the early 1970's – were reductions of *at least* 20% below what they would have been in the absence of these legislative changes, had all other factors been the same. In the three areas of taxation, environmental legislation and labour legislation the inescapability of trade-offs between further intervention on the one hand and employment and output on the other hand can no longer be ignored.

These are the *real* dangers that the nickel industry in Ontario and the land based nickel industry world wide, the worker in Sudbury and government must be aware of. The next section will deal with the effects that changes in consumption of nickel and changes in consumption forecasts may be expected to have upon the fortunes of the industry, and its workers.

Fig. 10

INCO'S Canadian Reserves

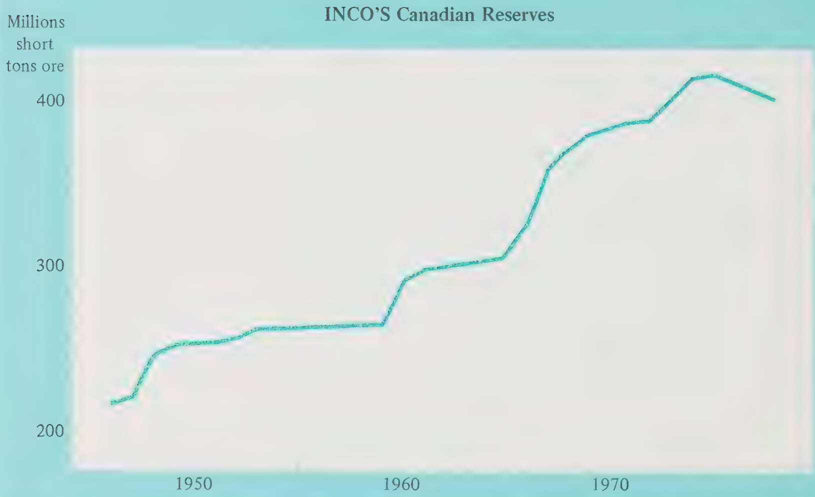


Fig. 11
INCO'S Canadian Reserves
Million short tons contained Nickel and Copper.

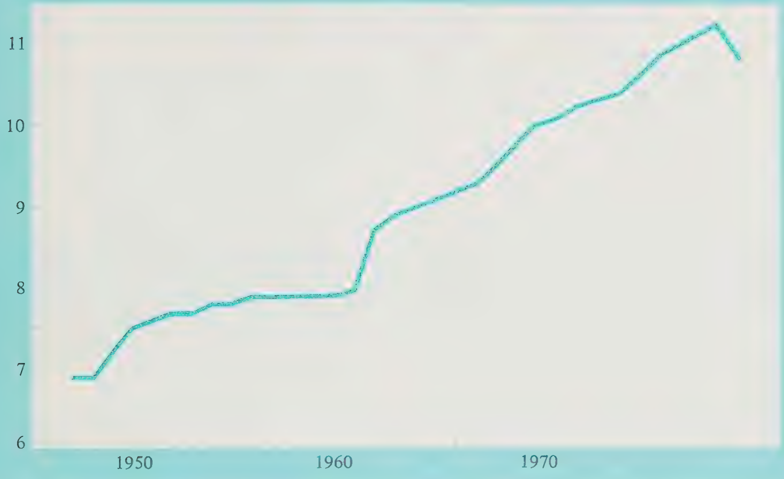
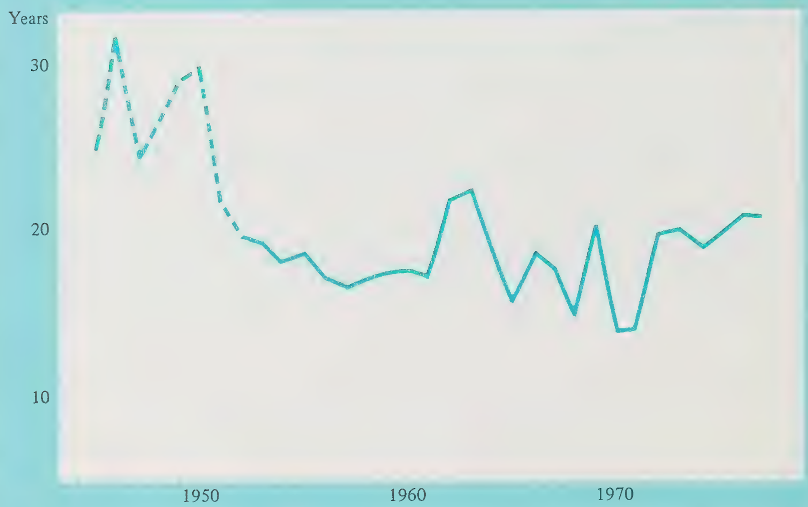


Fig. 12
INCO'S Annual Production
Millions of tons ore mined in Canada.

Fig. 13

INCO'S Canadian Reserve Ratio



V. Forecasting

One of the sources of concern on the part of nickel consumers over resource scarcity in the late 1960s and early 1970s was the spate of very high projections of future nickel consumption growth which at that time were prevalent in industry, government and academic circles. These high projections were based on serious misreadings of past trends. It was the massive gap between these nickel consumption projections and estimates of available production capacity, based on industry plans at this time, which led to anticipations of massive price increases in real terms for nickel in the late 1970s and early 1980s. This in turn led to the search for exotic sources and technologies and sea bed nodules filled that bill. Let us see what the faults of these high consumption projections were.

Forecasters generally took nickel consumption data, either from the beginning of the century or from the end of World War II to the early 70's, and fitted to them a compound growth curve. This was then extended to the year 2000. Such a curve generally reflected a compound growth rate in nickel consumption of around 6% a year without recognition that sustained exponential growth would be a novel phenomenon. Depending on whether these growth curves were derived from the longer or the shorter time period above, consumption of between 2.5 and 3.5 million metric tons of nickel was projected for the year 2000. This is represented in Figure 14 as the range of some projections made in the late 60s and the early 70s.

The Ontario Ministry of Natural Resources was among the first to interpret the past pattern of nickel consumption differently and to come up with different projections and publish them. In Mineral Policy Background Paper No. 4: *Towards a Nickel Policy for the Province of Ontario*, published in December 1977, it was held that nickel consumption world-wide in the year 2000 would be between 1.37 and 1.67 million metric tons – if one took a rather optimistic view of the future. A consumption level of between 1.1 and 1.2 million tons was considered the most likely. These consumption figures for the year 2000 compared with an estimated 1980 nickel production capacity of around 1.1 million tons. In other words, existing land based world productive capacity for nickel was sufficient to meet probable world demand until about 1995.

Since the publication of this paper, another study conducted by the Ontario Ministry of Natural Resources, published as Mineral Policy Background Paper No. 8 in August 1979 and entitled *World Mineral Markets: An Econometric and Simulation Analysis* confirmed the Ministry's earlier consumption growth estimates. The "most likely" scenarios also suggest small but steady increases in the real price of nickel. Other forecasters have now started to revise their consumption estimates downwards. Thus a forecast of the U.S. Bureau of Mines of May 1979, based upon a 3.2% cumulative growth rate from 1977, yields a nickel consumption of 1.45 million tons for the year 2000 and projections of April 1979 by Sumitomo are in the same range. The current industry consensus thus agrees with our earlier "optimistic" rather than our "most likely" forecasts.

On the other hand a World Bank report of June 1978 still assumes a growth rate in consumption of between 5% and 6% per year, and an UNCTAD report of August 1978 estimates for the year 2000 total world production of about 4.5 million tons of which about 3.8 million tons would come from land based production. The UNCTAD report presumably assumes that consumption would be adequate to dispose of these production levels.

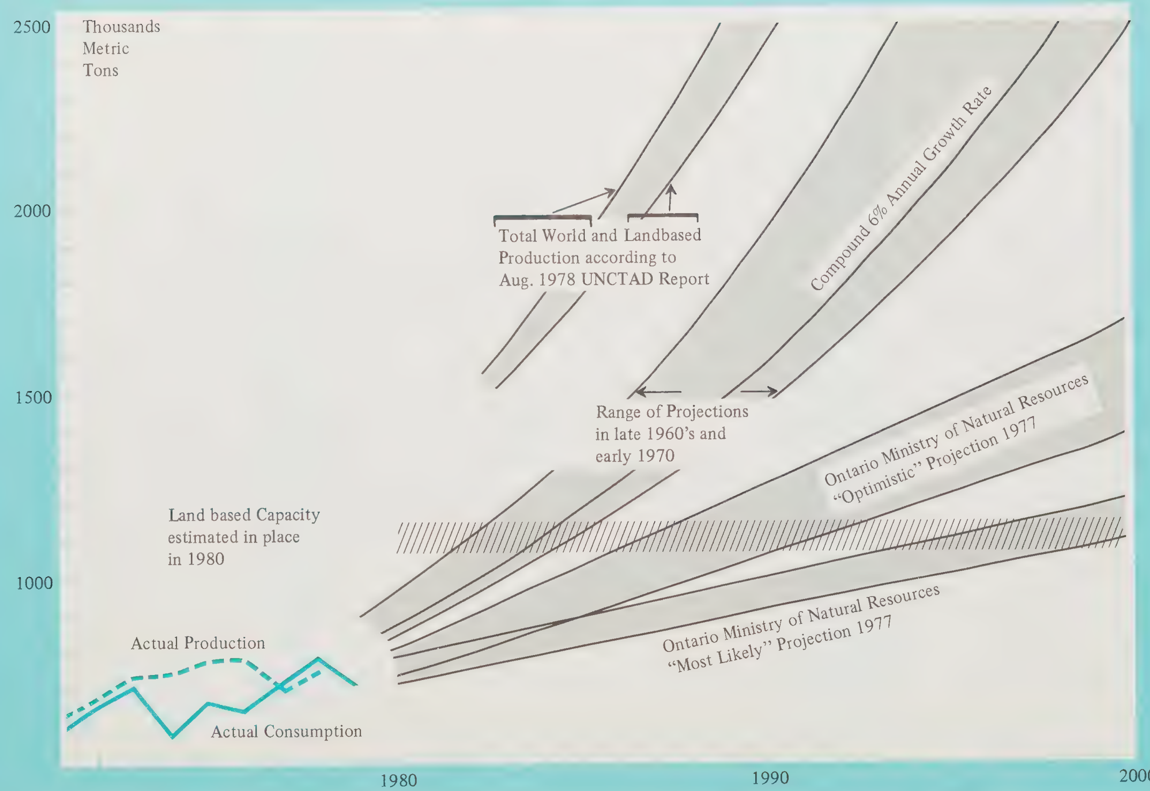
No forecast as to what is going to happen in the year 2000 is certain. However, the reader may form his own opinion by looking at Figure 14, and if he wants to go further, by reviewing some of the references cited. Figure 14 gives actual consumption and the trend of this consumption from 1972 to 1979. It shows the projections made in the late 60s and early 70s and the projections made by the Ontario Ministry of Natural Resources during the last two years, which, incidentally, have been based on the same information available to the forecasters who arrived at the 5% to 6% compound growth rate projections. *If the Ontario Ministry of Natural Resources "most likely" projections are anywhere near correct or if their extremes bracket the actual trend, then there will not be much scope for economically competitive (unsubsidized) production from sea bed nodules before the year 2000.*

We have to note here that the bulk of the land based production that will almost entirely satisfy the estimated year 2000 consumption is already in place and most of it is written off, while massive new investments would be necessary to start significant sea bed production, investments which would have to be made under conditions of extreme uncertainty. On the other hand, potential developments of identified land based resources in less developed countries while also expensive, involve much better known factors. Such developments together with capacity re-activations and capacity expansions of sulphidic mines would fill much of the greater demand if our "optimistic" consumption forecasts are correct.

In the next section some facts pertaining to sea bed nodules, to the Law of the Sea Conference and to the potential for competition of sea bed production with land based mines will be reviewed.

Fig. 14

Changing Nickel Consumption Forecasts



VI. Some Facts about the Sea Bed Nodules

The existence of manganese nodules has been known since they were first dredged up from the ocean bed by the Challenger expedition in 1873. These first samples came from an area several hundred miles north of Tahiti. Today it is well known that most of the earth's oceans contain nodules of varying size, composition and density. However, only some areas in the North and Central Pacific can be seriously considered for the early sea bed ventures. Mineral content (dry-weight) is 18-24% manganese .75-1.25% nickel, .50-1.15% copper and .25 to .35% cobalt. (This compares with Sudbury grades of 1.4% nickel, 1.2% copper, and \$5.00 to +\$10.00 per ton mined of cobalt, silver, gold and platinum metals). The most likely area for initial sea-bed mining would lie south of Hawaii, between 110 degrees west of Greenwich and the International Date Line, and between 6 degrees 30 minutes north and approximately 20 degrees north of the equator. (Figure 15). This covers an area of approximately 10 million square kilometres. Out of this area approximately six million square kilometres have a nodule density of more than 9 kilograms per square metre. The area of highest potential yield (shaded on map) covers about 800,000 square kilometres and lies about one-third of the way from Hawaii to the Galapagos Islands.

D. Pasho suggests the following on the basis of analysis using a 'Monte Carlo' method (simulation methods which use random devices for analysing complex stochastic processes), for the areas most likely to be mined first:

"We can be very confident (90% certain) that the quantity of recoverable nodules is not less than 270 million tons and not more than 8500 million tons. Expressed differently, there is a 95% chance that the amount of recoverable nodules is at least 270 million tons and a 50% chance that there will be at least 2000 million tons, but only a 5% chance that the amount exceeds 8500 million tons.

"We can be very confident (90% certain) that the quantity of recoverable nickel is not less than 3 million tons and not more than 76 million tons. Expressed differently, there is a 95% chance that the amount of recoverable nickel is at least 3 million tons and a 50% chance that it is at least 19 million tons, but only a 5% chance that the amount exceeds 76 million tons.

"We can be very confident (90% certain) that the quantity of recoverable copper is not less than 2 million tons and not more than 70 million tons. Expressed differently, there is a 95% chance that the amount of recoverable copper is at least 2 million tons and a 50% chance that it is at least 17 million tons, but only a 5% chance that the amount exceeds 70 million tons.

"For comparison, land based "world reserves" (mostly economically recoverable) were estimated in 1974/75 to be 55 million metric tons of nickel and 383 million metric tons of copper." This "world reserve" of land based nickel implies on the basis of our "most likely" forecasts a reserve ratio of over 40 years.

There is still some doubt as to how these nodules were formed. Most of them seem to consist of accretions of iron and manganese minerals around a core of some foreign substance, such as bone fragments of sea dwelling mammals or fish or around shark's teeth. The average depth from which nodules would have to be recovered is between 5000 and 6000 metres. A recent German article illustrated the difficulties that are encountered in prospecting alone to an extent that would be adequate for mine planning. The task would be equivalent to that involved in surveying by plane from 5 to 6000 metres high an area equal to most of the U.S. eastern seaboard. This would have to be done at night and under varying cloud cover and in sufficient detail to recognize and map vertical differences of ± 10 metres, to locate, so that they can be found again, every obstruction that is larger than an automobile, and to determine the amount and quality of nodules the size of potatoes. Additionally the survey would have to investigate and map the ground conditions underneath the nodules as to their carrying capacity and shear strength, all that from 5 to 6 kilometres high.

It is presently estimated that an extraction unit would have to have a capacity of at least 3 million tonnes per year. This would yield at best 35,000 tonnes of nickel, 30,000 tonnes of copper, 5,000 tonnes of cobalt and 63,000 tonnes of manganese. In other words, the size of one operation – approximately one quarter of Sudbury's production – would be sufficient to satisfy approximately 5% of current total world nickel demands, of about 22% of current demand for cobalt, of about 3% of current demand of manganese and of approximately .3% of annual world demand for copper.

The feasibility of a 3 million tonne per year mining unit has not been proved yet. A consortium, composed of AMR, DOMCO, INCO and SEDCO has in early 1978 recovered in continuous operation several hundred tonnes of nodules from 5200 metres depth. In this case the collector, of the type so far considered most efficient, was approximately 2 metres wide and was dragged passively by a long pipe. For commercial application the collector width would have to be at least 20 metres wide – and this could not be dragged. This means that a collector would probably have to move independently at 5 kilometre depths on top of sedimentary slimes of questionable carrying capacity. The questions that have not been resolved yet, are the manoeuvreability of such a collector, whether a mine area could be completely cleared of nodules, what slopes the collector could master, either upwards or downwards, just to mention some of the more obvious ones. The mining efficiency, the pick-up rate, of any such machines that have not even been built, is strictly speculative and very high recoveries will probably never be approached.

However, there are many other problems that have to be resolved. The major one is of course, how the material, once collected, is to be continuously moved up to the surface. Once it has reached the surface and has been carried to land by an ore carrier there are some difficult metallurgical problems to be resolved. All in all, it is estimated that a full scale demonstration phase which would have to precede commercial application would cost at least between 60 and 150 million dollars. Under present conditions, it is estimated that the "new venture price" (the commodity price at which major new conventional mines could be commissioned) is in the range of $1.20 to $1.30 in 1979 U.S. terms per pound of copper, and between $3.00 and $3.50 per pound of nickel. This suggests that at the earliest – and only if all remaining technical problems can be satisfactorily resolved – sea bed mining could be seriously considered only when new major laterite deposits would be considered for development. Under present "most likely" forecasts by the Ontario Ministry of Natural Resources that means that the earliest time at which commercial exploitation without subsidies could be considered would be in the late 1990's.

Various consortia, combining firms from the major consuming countries, are eager to start in the 1980's.

ONE HAS TO WONDER WHETHER THIS IS BECAUSE FORECASTS OF FUTURE ENERGY COSTS MAKE LAND-BASED LATERITE MINING APPEAR SO COSTLY THAT SEA BED MINING SEEMS TO BE THE ONLY "SECURE" SOURCE TO SUPPLEMENT SULPHIDIC NICKEL IN THE FUTURE, OR WHETHER MAJOR CONSUMING NATIONS WISH TO "INTERNALIZE" PROCUREMENT OF BASE METALS WHATEVER THE COST.

Under both of these assumptions the probabilities and economic advantages of finding and developing further major land based sulphidic deposits seem to have been forgotten – an omission of major concern to Ontario and Canada. Furthermore, forecasts of massive increases in energy cost for lateritic producers are as was mentioned earlier less than absolutely certain. It may also be held that security of supply and internalizing of procurement costs through sea bed mining are predicated upon very stable political and economic conditions – the very conditions under which the consumer has least to worry about these issues.

Fig. 15

Location of 'most likely' first mining sites

VII. The Law of the Sea Negotiations as they relate to Sea Bed Mining

The United Nations Law of the Sea Negotiations have been going on for over a decade now, and cover a vast number of topics, all of which will be covered in the final treaty. For the present purpose only those directly related to sea bed mining are of concern. They key concept governing sea bed mining aspects of Law of the Sea Negotiations is that ocean resources are considered to be the "common heritage of mankind". This concept was introduced in 1967 and accepted in 1970. Governed by this concept the negotiations moved towards an international arrangement, which would assure that some of the financial yield from sea bed mining would be available for distribution to nations other than those directly engaged in sea bed mining ventures, and particularly be available to contribute to the development of underdeveloped nations. This is to be done under United Nations auspices, by the raising of revenue from private sector sea bed mining ventures as well as through operations carried out by the International Sea Bed Authority. The Authority would eventually become a major nickel supplier in its own right.

Canada has a record of achievement in restructuring traditional principles of the Law of the Sea and in developing new ideas on ocean resource management. The United Nations Conference on the Law of the Sea has provided multilateral endorsement of some issues like Canada's 200-mile fishing zone, the 12-mile territorial sea, the concept of the submerged continental margin and the special pollution prevention legislation in ice covered waters. As in prior years, Canada and Ontario devoted much effort during 1979 to resolving extremely difficult outstanding Conference issues, particularly those concerning the proposed international system for deep sea bed mining, a matter of obvious significance for Canada – the world's largest producer of nickel.

Negotiations concerned first of all the proposed international regime of exploitation for the deep sea bed, in particular resource policy, the financial organization of the International Sea Bed Authority and of the "Enterprise", as well as the various arms of this Authority. The proposed "Enterprise", to be created by the U.N. International Sea Bed Authority, will develop portions of the sea bed, as well as private and public corporations or consortia.

It was of concern during a period of rapidly rising nickel consumption and consequently high expectations for continuous price rises, that the development of sea bed nickel capacity would be forced at too high a rate. This would lead to massive disruptions of world nickel markets if overoptimistic consumption forecasts did not materialize. From the Canadian point of view, one most important event was the conclusion in mid-1978 of an *ad referendum* agreement between the Canadian and American delegations, to which Ontario contributed, on a formula for putting a ceiling on nickel extraction from the deep sea bed. The formula would provide for an orderly growth in mining of the deep sea bed, give satisfactory safeguards against disruption of the land based mineral market, and would set a high enough ceiling on nickel production from the deep sea bed to meet the levels of future consumption of nickel. The "ceiling" formula for licensing of sea bed enterprises (an enterprise being the basic unit of nodule mining), was proposed under Canadian-U.S. leadership and is now included in the Law of the Sea Negotiating Text. While nickel is the controlling factor in the formula, the copper and cobalt recoverable from the nodules are also of influence.

According to this formula the *ceiling* for sea bed production for any given year was calculated as a percentage of the expected growth which in turn was determined by extrapolation from the previous 15 years' nickel consumption growth trend. The basic concept underlying this formula is illustrated in Figure 16. This diagram and the following description over-simplify the formula and are only meant to illustrate the principle. From the growth trend during the 15 years preceding the decision to authorize a sea bed venture, AB, the growth trend for a subsequent time period, BE, is extrapolated. The maximum tonnage of nickel to be produced from sea bed ventures is calculated as a proportion of this growth trend: e.g. in year C maximum sea bed production will be DE and guaranteed (by implication) land based production CD. Over the total numbers of years BC the total land based production would then be BBCD and total sea bed production BDE. If actual consumption after the issue of the license is less than forecast, that is if it lies below the line BE, sea bed and land based production compete for sales. If actual consumption after issue of the license is more, sea bed and land based production share the benefits. *No price controls or rationing are necessary*. Quite recently however, a shift in the negotiations became discernible. It became apparent that among some nations intending to engage in sea bed mining, there was developing increasing support for the concept of not just a ceiling, but also of a *guaranteed "floor"* to sea bed production licensing. The floor formula would be calculated in a way similar to – albeit more arbitrary than – the ceiling formula, however, the interpretation would be different.

There does not exist a clear-cut definition of the 'guaranteed floor' concept. The wordings used in debate seem to suggest that only licensing of sea bed production capacity is involved. The logic of the concept clearly implies that the concept will have to be expanded to encompass guaranteed minimum sales at specified prices, certainly from the beginning within the national economies of states backing private sector consortia and later on internationally, once Sea Bed Authority operated units start producing. In the following analysis, therefore, this logically necessary concept of a "guaranteed floor" applied to sales is employed.

A technical problem with both formulae arises from the fact that, going by the experience of the past decades, extrapolations from 15 year log-linear regressions change as earlier years are dropped from and new ones added on to the base period with the passage of time. Figure 17 illustrates how these changes occurred between 1950/72 and 1969/79 base periods. Sea bed production formula values would change accordingly.

Looking again at Figure 16, the future consumption at time of application for a sea bed mining venture would again be calculated from the actual trend AB as future trend BE and future licensed sea bed production would again be defined as the area BDE. However, over a time period BC this would now represent an aggregate tonnage (or for any given year between years B and C, the vertical distance between BE and BD would give an annual tonnage) that sea bed ventures would be guaranteed to produce. If actual consumption is less than forecast, if the trend changes illustrated is Figure 17 continue, for example, and consumption moves along the track BE', sea bed producers in year C would still be guaranteed the amount of production equivalent to DE, now D' E', whereas land based producers would have to reduce their output from CD to CD'. That makes it quite possible of course, that the land based output in year C would be less than in year B, in which the decision to authorize a sea bed venture has been made, e.g. that the distance CD' as in the case shown is less than the distance BB. Under tight markets it is almost certain that unit capital costs of producing sea bed nickel would be higher than the unit costs of producing land based nickel, as major established land based operators have likely written off all or large parts of their capital expenditures, while the capital expenditures of sea bed operators remain to be amortized. Sulphidic mines also have the option to highgrade and may be able to some extent to offset low base metal prices by higher platinum group metal byproduct prices. Sea bed nickel then could well be more expensive than land based nickel. *In that case, designated consumers would have to be forced to purchase specified amounts of sea bed nickel, at prices different from and higher than those of land based nickel.* To be successful, this would require the agreement and support of *all* major nickel consuming nations in the Free World to impose economic controls of far-reaching impact upon the very nature of their societies.

In summary, under the ceiling formula the *maximum* amount of sea bed production licensed would be determined and the sea bed enterprises would have to compete with their licensed production on the world market for sales. Under a guaranteed floor formula it would be virtually assured – by national corporations operating under it – to sea bed enterprises that a specified *minimum* amount of the production would be sold in their domestic markets, displacing land based nickel sold on open markets. Any risk of less than expected growth in nickel consumption would under the guaranteed floor fomula be passed on to land based producers, who would have to curtail their production. If world wide nickel consumption were to rise at an increasing or at least not declining compound rate of above 6% per year, as was assumed at the time the ceiling formula was discussed and accepted by some, the guaranteed floor concept would be unnecessary. However during the last few years it has become increasingly apparent that world wide consumption growth will be far less than earlier estimated. This aspect of future development of nickel consumption was covered earlier. It has also become apparent that growth rates not only can fall for periods of several years, but under most realistic assumptions about world economic growth are indeed very likely to keep below the 4% and quite possibly even well below the 3% annual compound rate.

The problems associated with the guaranteed floor formula under present assumptions regarding future consumption growth can again be illustrated with help of Figure 16. As the ceiling formula and the guaranteed floor formula are both calculated on the previous 15 years consumption trend, it is quite possible, that as years are dropped at the beginning of the trend calculation period and as new years' data are added at the end, i.e. as both points A and B on the horizontal axis move towards the right, the new trend extrapolations will fall with each application either above the line BE or – in light of the historic developments illustrated in Figure 17 – more likely below it. This would introduce considerable uncertainty into the long-term planning process of sea bed mining corporations, as, until the date of application for new ventures, they could never be sure whether or not the recalculated formula would allow for new sea bed mining authorizations. In practical terms it would mean that neither the sea bed authority nor the applicant would know whether there was scope, according to the formula, for a high new tonnage of sea bed capacity or for none at all, as the trend extrapolation would fluctuate from year to year.

The next section will discuss briefly some economic implications of the introduction of sea bed mining.

Fig. 16

The Principle governing Production of Sea Floor Nickel

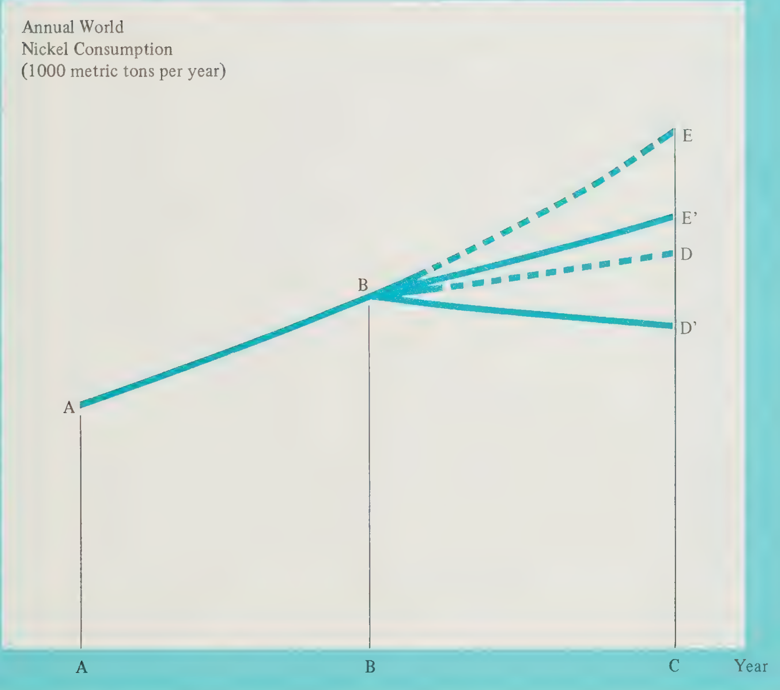
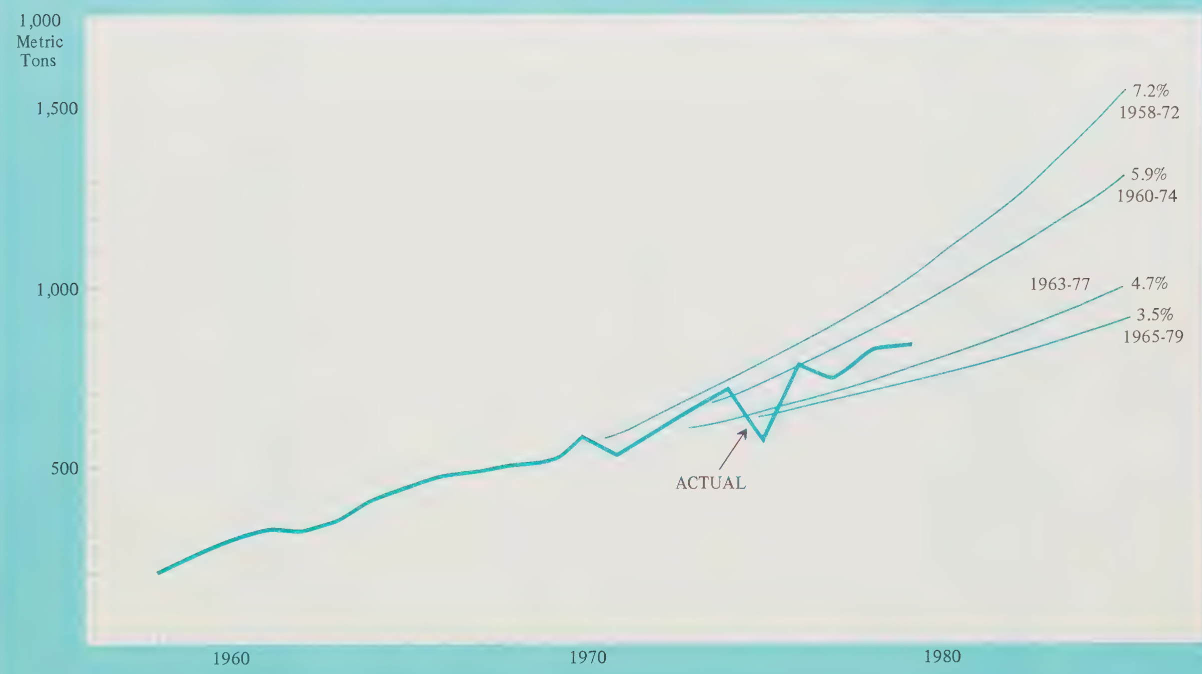


Fig. 17

World Nickel Consumption Trends
15-Year Log-Linear Regressions



VIII. On the Future for Sea Bed Mining

Nodule mining provides a textbook example of the economics of introducing non-conventional technology. The basic economics involved are explained in Appendix I. It is of the essence, under open market conditions, that

a) non-conventional technology will only be economical at higher prices – if it could supply the market at or below current prices it would already be incorporated into the structure of production and

b) higher expected future prices, estimated on the basis of conventional technology, will not be quite realized if unsubsidized non-conventional technology is introduced.

If expected future prices, *significantly higher in real terms* than current prices, are not realized, which is probable under present 'most likely' forecasts – although this scenario may in the opinion of some underestimate energy cost impacts on laterite production – sea bed production would not "take off" in the near future without subsidies.

If then the production formula is used by the major consuming/importing countries to specify a guaranteed floor – with the objective then to force sea bed mining development against all market signals – a two-tier allocation system for nickel would have to supplant the present market system. This non-market allocation system would, by forcing higher prices on nickel consuming industries and ultimately on consumers of nickel containing products everywhere, assure non-economic sea bed producers of a subsidy.

The key point for Canada as a land based producer – as well as for other land based producing countries – is that under a "guaranteed floor" formula the risk of disappointed expectations as to future nickel market improvements would be shifted entirely from the sea bed operator to the land based operator.

Looked at differently a "guaranteed floor" formula would also shift the burden of investment risk from investor to consumer and taxpayer.

IF THE ADVOCATES OF THE GUARANTEED FLOOR CONCEPT TRULY BELIEVED IN THEIR FORECASTS, THE GUARANTEED FLOOR CONCEPT WOULD NOT BE NEEDED, AND THE ADVOCATES WOULD BE WILLING TO ASSUME THE INVESTMENT RISKS OF SEA BED DEVELOPMENT.

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Appendix I

The Economic Analysis of Sea Bed Mining

Nodule mining provides a textbook example of the economics of introducing non-conventional technology. The basic economics involved can be explained with the aid of Figure 18. In this figure the vertical axis represents the price per pound of nickel and the horizontal axis presents quantitites of nickel, say million pounds per year. S_c S_c represents the current supply schedule using conventional technology of the industry prior to the introduction of the non-conventional technology of sea-bed mining. Every point on this line gives the quantity of nickel which industry is prepared to supply per year at any given price from conventional land based sources. The line D_a D_a represents the actual demand schedule of all consumers of nickel. The two curves intersect at point A which gives the equilibrium price (i.e. at the current time a price per pound P_1 prevails while a quantity of Q_1 is bought and sold per year).

The supply curve for nickel produced by the non-conventional technology of sea bed mining is represented by S_n S_n. This curve starts at P_n on the vertical axis. This means that at a price of less than P_n *no* sea bed nickel will be produced. When the price of nickel exceeds P_n, S_n S_n is *added* to S_c S_c, the supply curve for conventionally mined nickel; joining it the total supply curve is then the summation of the two $(S_n + S_c)$ at B, a point which lies above A. Conditions under which sea bed nickel is more expensive than land based nickel would be represented by points between P_n and B. Under such conditions the non-conventional technology would not be introduced. At a price higher than P_n, an *additional* quantity of nickel will enter the market. Non-conventional technology thus *supplements* traditional sources of supply, it does not replace them.

At the time at which the introduction of non-conventional technology is first considered (assuming no subsidization), it must be expected that in a future time period prices will be higher than currently. This can come about either by a forward shift of the demand curve from D_a D_a to D_e D_e, that is through an increase in expected demand such as illustrated in Figure 18, or through a backward shift of the supply curve S_c S_c. This latter case is not illustrated and only the former case will be used in the following. Should the price rise result from a backward shift of the supply curve rather than from a forward shift of the demand curve, the analysis would not change in any essentials. With the shift of the demand curve from D_a D_a to D_e D_e, the future price of nickel *in the absence of new technology* would be P_3 and the quantity bought and sold would be Q_4. The introduction of the new technology however would lead to an intersection of the D_e curve with the total supply curve $(S_n + S_c)$ at C. This means that, providing the advance calculations of the costs of sea bed mining are correct, the price would be P_2 and the quantity bought and sold would be Q_3 of which Q_2 would as before be drived from land-based mining and the quantity Q_3-Q_2 from sea bed mining. Expected price with non-conventional technology – P_2 – will be *lower* than without it – P_3. The division of the supply between conventional land-based operations and non-conventional sea floor mining is determined by the intersection of the price line P_2C – with the S_c curve at D. If the expected shift of demand from D_a to D_e materializes and if the quantity Q_3-Q_2 is less than that provided by the ceiling formula, points C and D would indeed represent the market equilibrium situation between land-based and sea-based mining. If on the other hand a ceiling formula or a downward revision of a ceiling tonnage constrains the output of a sea bed operation so as to adversely affect economies of scale this would be equivalent to an increase in the price of non-conventional technology and the total supply curve $(S_n + S_c)$ would be moved upwards. The equilibrium price would be somewhat higher than P_2 and the total quantity bought and sold somewhat lower than Q_3.

Let us now consider what happens if the demand shift expectations represented by D_e are not realized. For simplicity's sake let us consider now what happens if the shift for the future is not from D_a to D_e but from D_a to D_x which intersects S_c at point F to the left of point A. In the absence of controls, or if the production formula specifies a sea bed production ceiling, there would be no sea bed production, the price would be P_4 and the quantity bought and sold Q_5 (although for ease of graphical representation we are considering an actual drop in demand in the future rather than merely a less than expected increase, the analytics would be the same for the latter case). If we assume now that the sea bed production formula were used to specify a guaranteed floor rather than a ceiling the amount of guaranteed sea bed production would still be Q_3-Q_2 which could still be produced at a price of P_2. This guaranteed sea-floor production would have to be deducted from the total quantity demanded Q_5 which would give a total demand from conventional producers of Q_6. (This interpretation requires a great many simplifying assumptions. In reality the situation would be *much* more complex). However, this relatively small demand could be met by conventional producers at a price of P_5 by closing down high cost operations and highgrading surviving ones. The total available markets for Q_5 would now be faced with supplies Q_6 at a price of P_5 plus Q_5-Q_6 (equal to Q_3-Q_2) at a price of P_2. Naturally no buyer would voluntarily buy nickel at P_2 if nickel at P_5 were available, and the need to impose the allocation to each consumer of specific amounts of sea bed nickel at a high and land-based nickel at a lower price would arise. There is no question that for each customer the actual price of nickel would be a weighted average of the prices and quantities of land and sea-based nickel involved. How this *average* price would compare in any specific case with the actual free market price from land-based operation alone must remain open as it would depend on the elasticities of the supply and demand curves. As a generalization it is fair to say that if for any

given time period the proportion of guaranteed sea bed nickel to land-based nickel is small, this average price might be only insignificantly higher than the alternative free market price but that it may well be significantly higher in a time period for which the guaranteed amount of sea-bed nickel constitutes a significant proportion of land-based nickel, as would be the case after licensing even two or three "enterprises" under the guaranteed floor formula.

The weighted average price for nickel would very definitely be higher than the land-based nickel price alone if at the reduced level of utilization of land based capacity the S_c curve becomes horizontal (perfectly elastic), that is that no further price reductions are associated with further quantity reductions. This is represented by S_c' which may join S_c at any point below A. If D_x either intersects S_c' (P_4 would be equal to P_5) – or intersects S_c so that the vertical on Q_6 intersects S_c' that the difference between P_4 and P_5 becomes very small, the weighted average price will definitely be higher than the land-based price. Under current industry structure and under 'most likely' forecasts this latter case would be very likely, throughout the 1980's and well into the 1990's.

Far more important, however, than any *hypothetical shortrun implications* of forced allocation under a "guaranteed floor" formula upon weighted average price and aggregate demand, would be the *certain and adverse long-run implications* for overall industry efficiency. The ultimate result of the adoption of a "guaranteed floor" concept, whatever the initial formulation, would be world wide imposition of the principles of the command economy upon a truly crucial heavy industry subsector. This can today only be defended by one ideologically committed to the substitution of a morally and tehnically inferior means, the allocation system of the command economy, for a morally and technically superior means, the market system of the capitalistic economy, of organizing the flow of resources to their socially most highly valued uses.

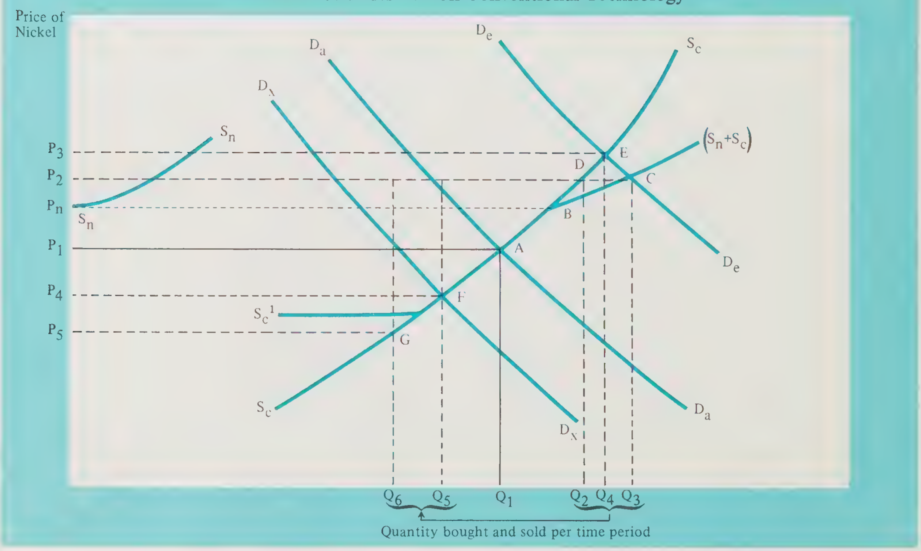
Summarizing the technical argument, non-conventional technologies are usually discussed at a time when significant increases in demand and considerable price increases are expected for the future assuming that under these expected higher prices a new technology can supply some of the larger market at a lower price than the current technology. It is of the essence, under open market conditions, that

a) non-conventional technology will only be economical at higher prices – if it could supply the market at or below current prices it would already be incorporated into the structure of production and

b) higher expected future prices, estimated on the basis of conventional technology, will not be quite realized if non-conventional technology is introduced.

The very real dangers of interventionist policies to individual liberty and economic advance issue in today's world from the conclusively refuted and no longer tenable ideas associated with the writings of Galbraith, the "Club of Rome" and with the 'New International Economic Order.'

Fig. 18
The Economics of Non-Conventional Technology



Appendix II

Excerpts from: Law of the Sea Conference-Resumed Eigth Session, New York, July 19 – August 24, 1979
Assessment by the Canadian Delegation

The resumed session of the United Nations Conference on the Law of the Sea convened in New York from July 19 to August 24, 1979 determined to build on the substantive progress achieved at the March-April Geneva session. The key objectives in New York were to attempt to resolve all the outstanding issues relating to the non sea bed mining issues and to narrow the remaining differences on the sea bed regime in order to prepare the way for concluding the Conference in 1980.

While not all the outstanding non sea bed issues were resolved, some important ones were settled and in any case the extent of differences was reduced on all problems still before the Conference. Accordingly, it was decided that the Conference should move at its next session into its final decision-making process.

Sea bed Production Policy – Nickel Production Ceiling:

Discussions were held throughout the session on the range of issues relating to the degree of displacement of land-based production of nickel, copper, manganese and cobalt by the proposed deep sea bed mining activities. The major concern of Canada and other land-based producers (LBP), as well as many other countries which are also concerned to ensure that the proposed international Enterprise is viable, was to prevent a nickel production "floor" being added to the previously negotiated ceiling which would be so high as to seriously damage the interests of land-based producers and substantially limit the markets available to the international Enterprise.

The problem arises out of the fact that major consuming countries have made clear their determination to become the major miners of the sea bed (at a ratio of at least 5:1 in comparison to the international Enterprise). Agreement on a "floor" above the estimated growth of the market (i.e. a guaranteed treaty right to produce up to a stated level of tonnage during specified periods irrespective of market conditions) would open the possibility that the major consumer/miner states could become their own major suppliers, leaving very little if any market other than domestic consumption, either for LBPs or for the proposed international Enterprise. Thus ten years of negotiations on a wide range of fundamental legal-political problems would have been put in jeopardy as a result of the decision on this single issue.

The LBPs do not object to a moderate floor sufficient to ensure that sea bed mining will not be disrupted during periods of low growth in demand for nickel, provided that the tonnage figures contained in it do not raise the level of the floor to the point that the ceiling concept becomes meaningless. The important point which must be recognized is that the ceiling formulation now embodied in Art. 151 (2) of the ICNT/Rev. 1 was carefully negotiated by the interested parties so as to accommodate the legitimate requirements of prospective sea bed miners for the mineral resources of the deep sea bed. Moreover, it has been carefully designed to respond to actual market growth, something which the "floor" is specifically designed to prevent.

For the most part, discussion of this matter took place in an *ad hoc* Negotiating Group under the Chairmanship of Ambassador Nandan (Fiji). This Group had been established in Geneva to deal with the production policy issue and is comprised of land-based mineral producers, including Australia, Canada, Columbia, Cuba, Indonesia, Zambia, the major mineral consuming countries, namely the USA, Japan and EEC member states, as well as Kenya as a potential producer.

The consuming states opened discussions in the "Nandan Group" by proposing floor tonnages in effect equivalent to a six percent annual growth in world nickel demand over the initial years of the interim period. This was subsequently lowered to 4.5 percent. These figures greatly exceed the 3.8 percent figure estimated by the USA Bureau of Mines as the most optimistic forecast of the likely future growth rate of nickel demand. The LBPs made clear that figures of 6 percent or 4.5 percent were non-starters.

During Ambassador Nandan's absence from the session, William Okoth (Kenya) chaired the Group and endeavoured to expedite serious negotiations on the floor issue. While his proposals were not followed up in detail, they did serve a useful purpose in turning the focus of the Group to the early years of the application of the production ceiling. Halfway through the session, the Working Group of 21 held a two-day debate on production policy issue. The representative of Peru, speaking as Co-ordinator for the G-77, suggested that negotiations should continue in the Nandan Group in order to determine whether the parties themselves could reach agreement.

This course of action was supported by the delegations of Indonesia, Cuba, Australia, Zaire and Iraq. Canada associated itself with the view of these delegations, i.e., that the preferable approach was to pursue active negotiations in the Group in an attempt to resolve the matter, rather than having the Chairman present his own proposal. The Canadian representative noted that the 4.5 percent floor figure proposed by the FRG was far from being the "reasonable middle-ground proposal" they had called it. Cuba also made the same point.

. . . . .

Although it did not prove possible to reach agreement on an "acceptable" floor, the difficulties among the several delegations were narrowed significantly. Negotiations on this and other production policy issues will be resumed at the ninth session in March 1980.

Deep Sea Bed Mining Regime: Common Heritage Concept:

The resumed eighth session saw significant progress in resolving two issues (decision-making in the Council and financial arrangements) which are crucial components in the creation of any international system designed to regulate the exploration and exploitation of the deep sea bed. However, hard bargaining will be required at the next session before both the developed and the developing countries can feel satisfied that the proposed treaty will promote and protect their respective interests.

Decision-making in the Council has long been regarded as one of the thorniest Committee I issues. Significant movement was nevertheless achieved in New York. The new voting proposal provides that a specific list of substantive issues will be subject to a two-thirds majority provided that a specific number of members, still to be settled, has not cast negative votes. There is hope that this procedure will be acceptable to the highly industrialized states which want voting protection for their deep sea bed economic interests and to the developing countries which firmly reject the idea of a veto by any group of states. However, the fear by the USSR and its allies that the number of negative votes likely to be decided upon will have the effect of excluding the Eastern European bloc from playing a pivotal role in the Council casts some doubt on the prospects for finalizing this matter easily.

Two aspects of financial arrangements are of particular importance to the highly industrialized states: the financial terms of contracts and the financing of the Enterprise. One major change in the proposed financial terms of contracts discussed at the New York session would appear to go some way to meeting one of the key demands of these countries, i.e. that the terms should be sufficiently flexible so as to take into account the capacity to pay of individual operators. However, degelations from a number of industrialized states still object to the level of the proposed rates since they are of the view that the calculation of the charges is not confined to the mining sector. These countries are also not entirely satisfied with the provisions on financing of the Enterprise because they consider the required cash contributions to be too burdensome on their national treasuries and they are pressing for the imposition of a ceiling on their potential liability. They also wish to ensure that the Enterprise will be subject to national taxation.

Further work was accomplished in filling in the remaining gaps in the text relating to the role of the Enterprise in reserved areas and joint ventures, to certain aspects of the qualification of applicants and to prospecting obligations. As a result, it would appear that not much more work will be required in order to complete consideration of these matters at the next session. In addition, the settlement of disputes provisions relating to sea bed matters were the object of further fine-tuning, thereby greatly increasing their acceptability to the highly industrialized states.

The session did not see substantive discussions on two very important outstanding issues, transfer of technology and the moratorium provision in the Review Conference article. Both are central, in the eyes of developing countries, to the finalization of the Committee I package of issues and it is expected that the negotiations on these two topics at the next session will be very difficult.

. . . . .

At the end of the resumed eighth session, the Conference specifically endorsed the President's proposal that the next session be of a decision-making character. . . If the anticipated programme of work is adhered to and negotiations concluded on the outstanding issues, a signature session will be convened in Caracas in the latter part of the year.

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